PAN in the Eastern Pacific Free Troposphere: A Satellite View of the Sources, Seasonality, Interannual Variability and Timeline for Trend Detection

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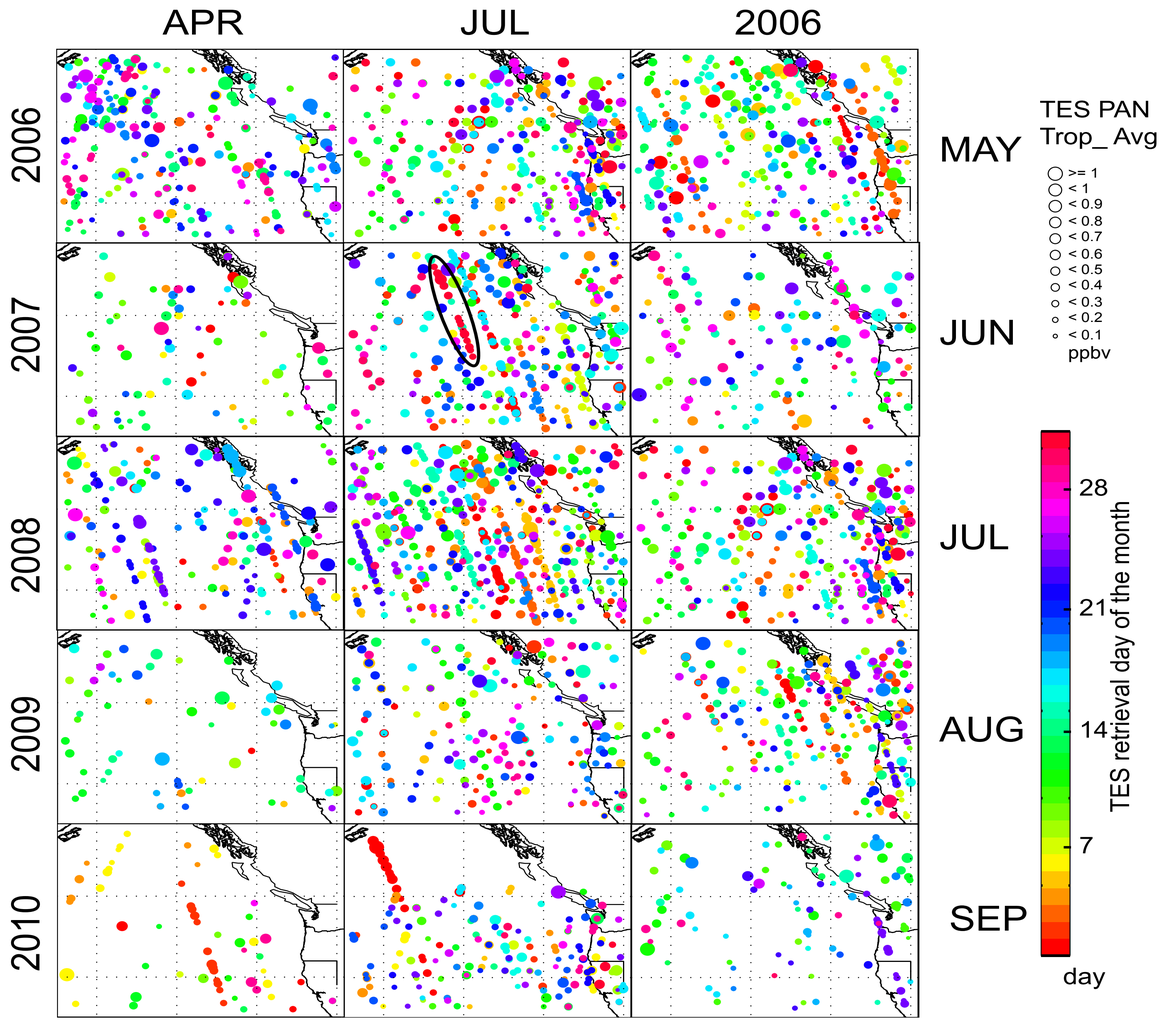
Introduction

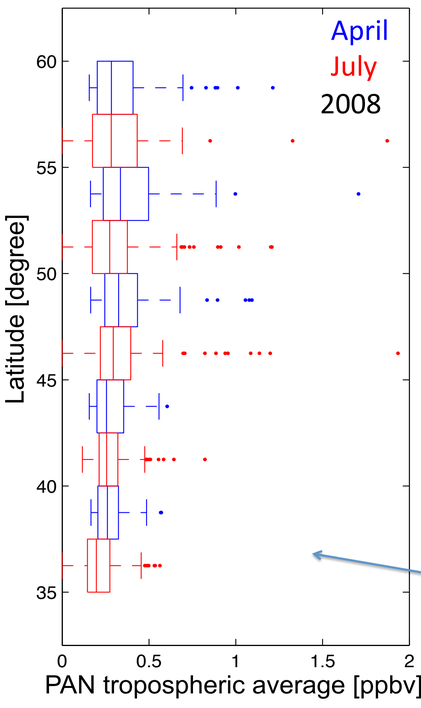
- Peroxyacetyl nitrate (**PAN**) is an important reservoir species for NO_x in the troposphere and plays a significant role in the redistribution of NO_x to remote regions.
- PAN comprises the dominant fraction of oxidized reactive nitrogen in plumes of Asian origin observed over the Pacific Ocean.
- PAN decomposition in specific plumes of Asian origin subsiding over the **eastern Pacific Ocean** can lead to significant O_3 enhancements.
- Though most past work in this region has focused on **spring**, model calculations by *Jiang et al.* [2016] show that the contribution of PAN to Asian O_3 export is also significant in **summer**.

TES PAN observations: interannual, seasonal variability

- **TES PAN observations**
  - Detection limit ~ 0.2 ppbv.
  - Peak sensitivity 400 – 800 hPa.
  - Only select data with DOFS > 0.6.

Plumes containing elevated PAN are presented almost every day in July.



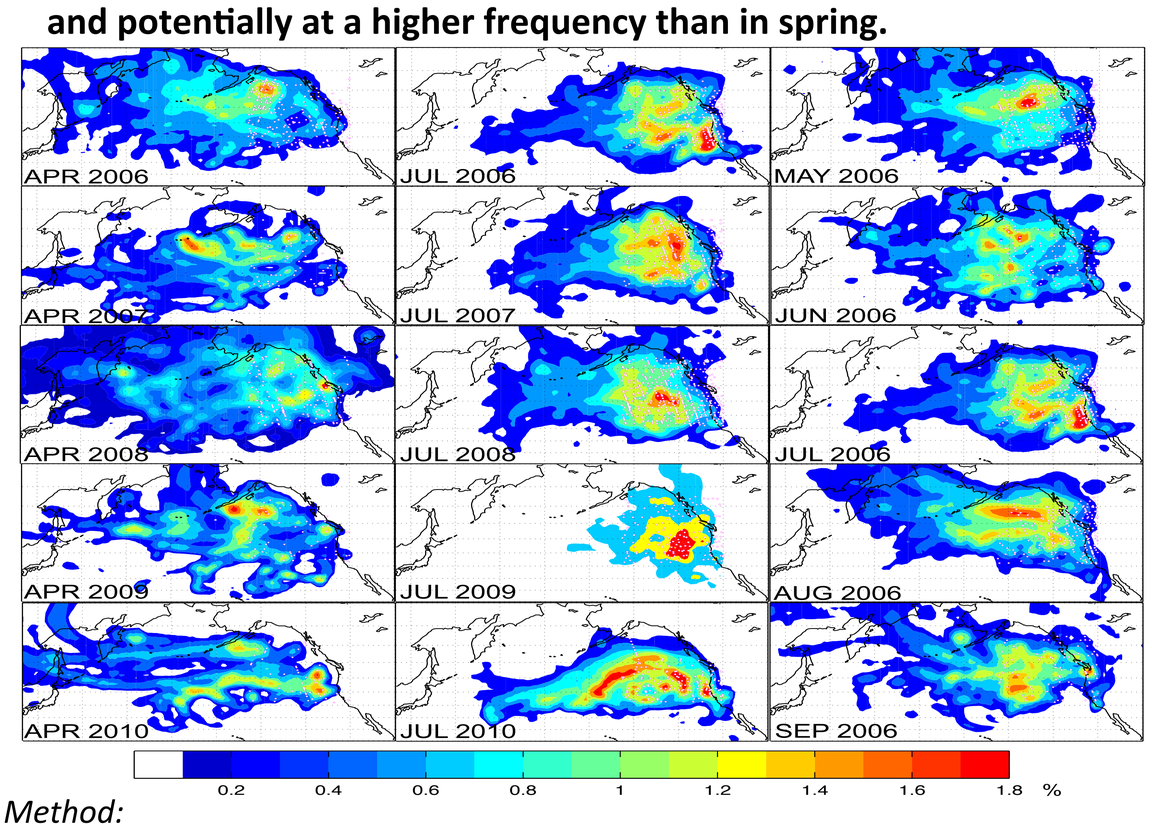


- There is a latitudinal gradient in the tropospheric average TES PAN in July 2006 and 2008.
- More TES PAN retrievals have tropospheric average PAN mixing ratios larger than 0.5 ppbv at high latitudes (> 45°N);
- The variability of the data at higher latitudes (> 45°N) is larger than that at lower latitudes.
- Consistent with model simulations in *Fischer et al.* [2014].

Binned by 5° latitude

Sources of PAN over eastern Pacific Ocean

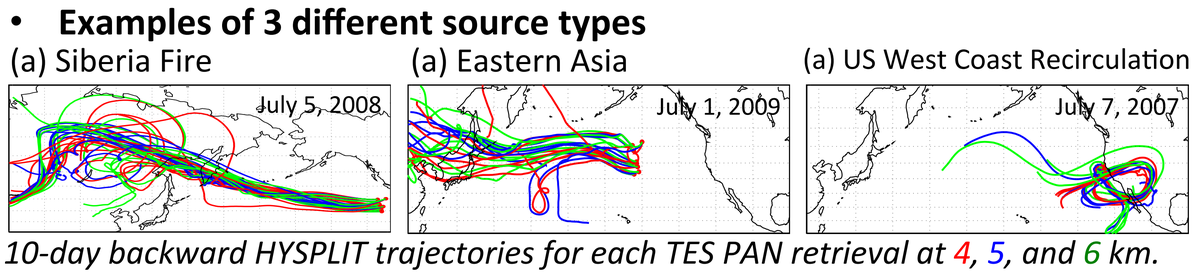
- **Trans-Pacific transport of PAN clearly also regularly occurs in summer, and potentially at a higher frequency than in spring.**



Method:

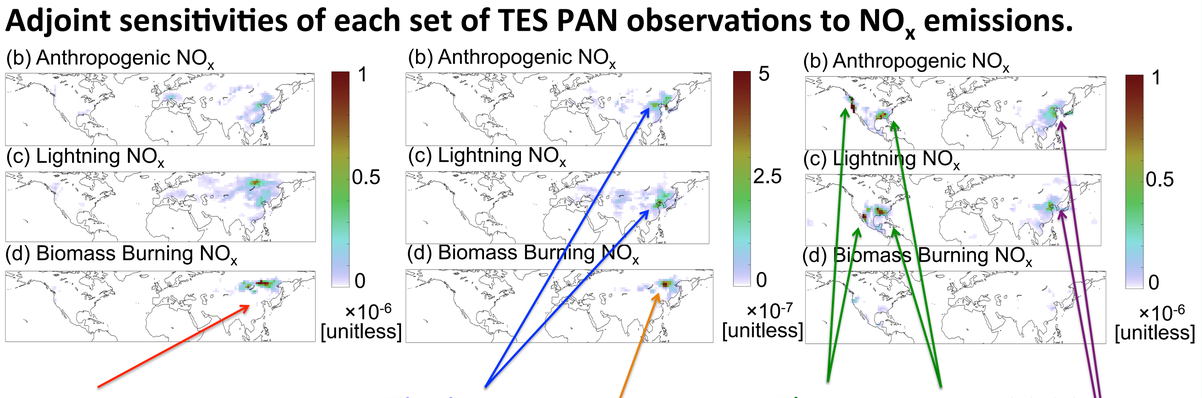
- *5-day backward HYSPLIT trajectories for each TES PAN retrieval at 4 km;*
- *Each 1° x1° grid cell was calculated as the numbers of trajectories passing through a 200 km radius of each latitude and longitude point divided by the total hours of each trajectory and the total number of TES retrievals.*

- **Examples of 3 different source types**



10-day backward HYSPLIT trajectories for each TES PAN retrieval at 4, 5, and 6 km.

Adjoint sensitivities of each set of TES PAN observations to NO_x emissions.



Timeline for trend detection using TES PAN

- To detect a trend* of a given magnitude in PAN, it would be **faster** to use satellite observations over the eastern Pacific Ocean region rather than surface in situ observations.
- A trend of a given magnitude will be **more quickly** detected in **summer** than spring in the TES PAN data.

Increasing rate in PAN (% year^{-1})	1	2	3	4	5	6
Years (based on April retrievals)	22	14	11	10	8	8
Years (based on July retrievals)	15	10	8	7	6	6
Years (based on springtime observations at MBO site, [*Fischer et al.*, 2011])	31	20	15	13	11	10

** A real trend is indicated at the 95% confidence level.*

Method:

- 4-day averages of the tropospheric average of all the successfully detected TES PAN retrievals; -> approximately 40 samples for all five years
- Randomly select 8 samples (number for a month) for each year of the trend;
- A hypothetical PAN trend (*e.g.* a 3% increase in PAN per year) was then added to these selected samples;
- Calculate the correlation coefficient of PAN against time and the t-statistic;
- Repeat this process 1000 times.

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